TR-12

TECHNICAL REPORT

CARIBBEAN CURRENT SURVEY

SPRING 1953

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Oceanographic Publications Branch
Division of Oceanography
and
LDCR. WALTER CHIMIAK, USN
Plans and Operation Office

OCTOBER 1955

U. S. NAVY HYDROGRAPHIC OFFICE
WASHINGTON, D. C.

ABSTRACT

Geomagnetic Electrokinetograph (GEK) observations by the USS PURSUIT, USS SAN PABLO, and RV ATLANTIS, and 21 oceanographic stations by the USS PURSUIT were obtained in the northern Caribbean area bounded by Cuba, Hispaniola, and Jamaica between 14 March and 9 June 1953.

The current system was found to be more complex than previously believed; current speeds were strong, often exceeding one knot, and an easterly drift along the southern coast of Cuba was observed at all times. Volume transport above 920 meters was calculated as $45 \times 10^6 m^3/sec$.

It is believed that the current system was undergoing change during both parts of the PURSUIT survey, since the subsequent surveys by the ATLANTIS and SAN PABLO found a reversed pattern of flow. Calculations of transport (excluding those sections where stations taken at both the beginning and the end of the survey were used in the computations) support the accepted theory of water movement from east to west. However, surface current measurements indicate a definite eastward drift.

The validity of dynamic calculations based on USS PURSUIT oceanographic station data is questionable in certain sections of the area owing to the transient nature of the circulation and the long period of time between occupation of the stations.

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FOREWORD

Information concerning permanent and transient features of current systems as well as the factors controlling these features is essential to the prediction of currents. Just as in the case of weather elements, current patterns existing at a given time may vary appreciably from the overall average portrayed on Hydrographic Office Pilot Charts. Thus, the difference between average and the actual currents existing between 14 March and 9 June 1953 are of particular interest in future studies and publication on currents in the Caribbean area.

During the period while he was Commanding Officer of the USS PURSUIT, LCDR Chimiak, USN, professionally conducted the field survey upon which this report is based. Miss Keen analyzed the survey data and prepared the technical report.

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I. INTRODUCTION

Between 14 March and 5 May 1953 the USS PURSUIT made a current survey in the northern Caribbean area bounded by Cuba, Hispaniola, and Jamaica. The survey consisted of 21 oceanographic stations (numbers 13-21, 33-42, 49 and 50)[1] and 50 Geomagnetic Electrokinetograph (GEK) observations. In support of this survey the USS SAN PABLO took 3 anchor stations and 69 GEK observations in the area during the period 29 May to 9 June 1953. The RV ATLANTIS (Woods Hole Oceanographic Institution research vessel) also took 116 GEK observations in the area between 18 March and 13 April 1953.

Dynamic height anomalies were computed from the oceanographic station data. Current patterns determined from dynamic topography are shown for the surface, 100-, 500-, and 1,000-meter levels relative to a reference level of 1,200 meters (figs. 1-4). The figures, with the exception of Windward Passage, show little change in the current pattern of horizontal flow to a depth of 1,000 meters. The current pattern at the surface with reference to 400 meters (where comparatively stable conditions were found) is shown in figure 5. A comparison of figures 1 and 5 shows that the greatest changes take place within the upper 400 meters.

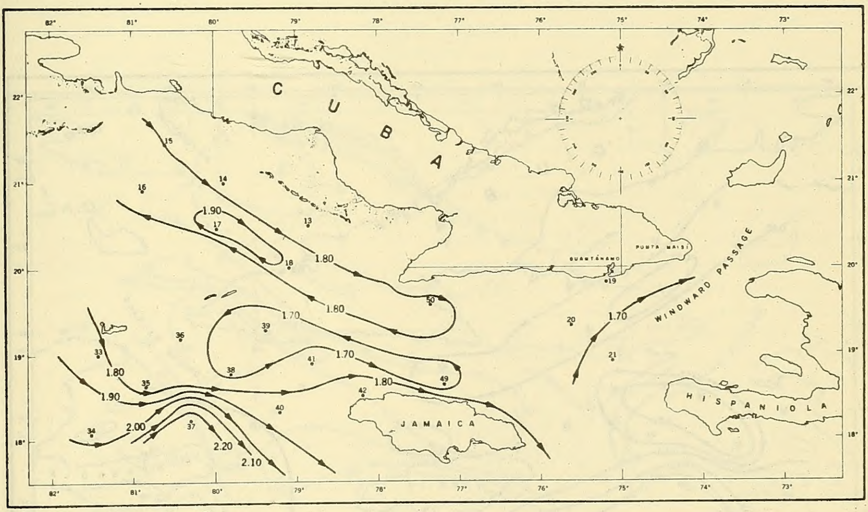

Fig. 1. Current pattern at surface determined from dynamic topography relative to 1,200-meter level

[1] Station data are available at the U. S. Navy Hydrographic Office.

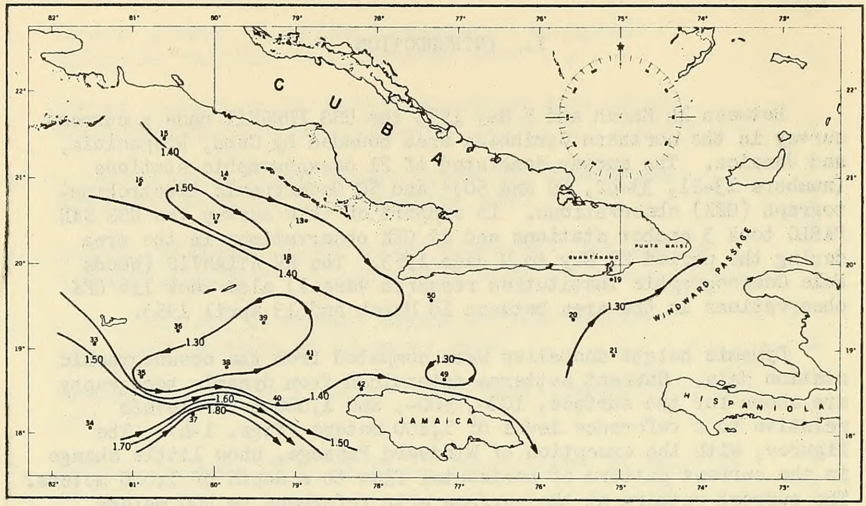

Fig. 2. Current pattern at 100 meters determined from dynamic topography relative to 1,200-meter level

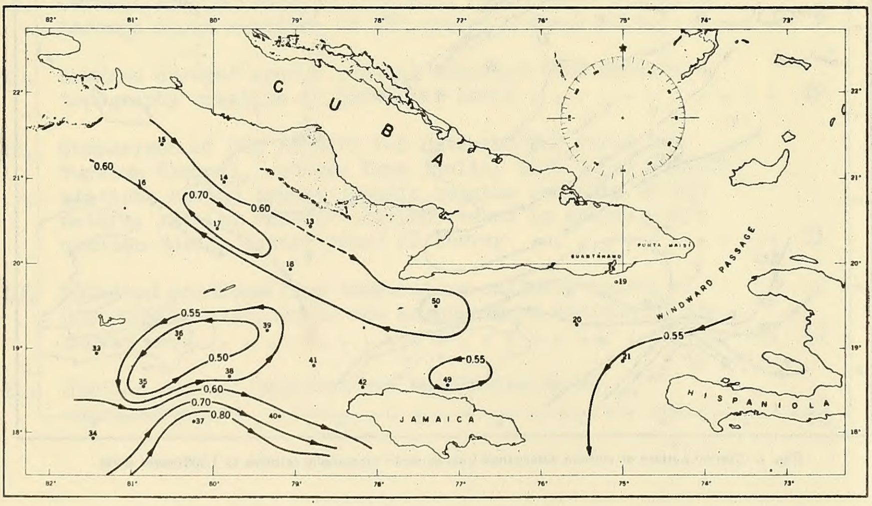

Fig. 3. Current pattern at 500 meters determined from dynamic topography relative to 1,200-meter level

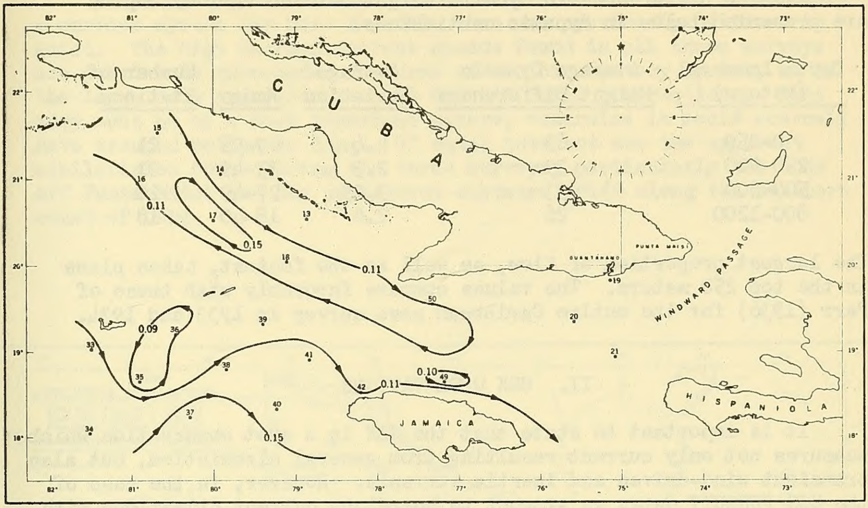

Fig. 4. Current pattern at 1,000 meters determined from dynamic topography relative to 1,200-meter level

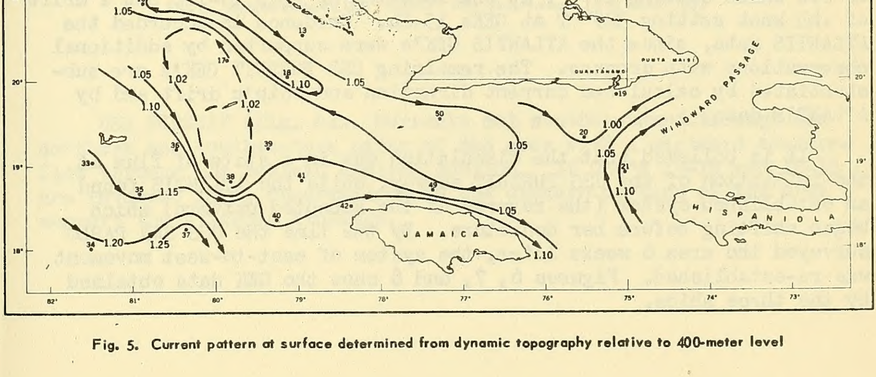

Fig. 5. Current pattern at surface determined from dynamic topography relative to 400-meter level

Average differences in dynamic height between various depths are presented below in dynamic centimeters:

Depth Interval (Meters)	Average Dynamic Height Differences	Average Deviation	Range	Number of Stations
0-250	83	4.6	69-95	21
250-500	39	2.3	33-49	21
500-800	33	3.25	27-49	20
800-1200	26	2.6	18-40	18

The largest proportion of flow, as well as the fastest, takes place in the top 250 meters. The values compare favorably with those of Parr (1936) for the entire Caribbean area survey in 1933 and 1934.

II. GEK OBSERVATIONS

It is important to state that the GEK is a spot observation which measures not only current resulting from general circulation, but also transient wind-driven and inertia currents. However, in the case of the USS PURSUIT data, an attempt to correlate current directions with local meteorological conditions met with little success, especially where discrepancies with ATLANTIS observations appear. The discrepancies are obvious, and since with two exceptions the USS PURSUIT GEK's were taken first, with a minimum time difference of 3 days whenever the two ships took observations at the same positions, it is concluded that the variations are significant, depicting the circulation prevalent at the time of observation. The two exceptions are USS PURSUIT GEK's 13-14 and 15-16, with speeds exceeding one knot. These were taken within an hour or two of ATLANTIS observations at the same locations, where the latter found equally strong currents running in opposite directions. It is believed that the electrodes on the USS PURSUIT's GEK were connected in reverse at these stations which would account for the 180° discrepancies. This belief is supported in part by the USS PURSUIT boat sheets which show a calculated drift of 2.8 knots setting 167° T at the location of GEKs 15-16, but a drift of .44 knot setting 329° T at GEKs 13-14. Credence is accorded the ATLANTIS data, since the ATLANTIS GEK's were supported by additional observations with drogues. The remaining USS PURSUIT GEK's are substantiated by calculated current direction and ship's drift and by ATLANTIS data.

It is believed that the circulation was in a state of flux at the initiation of the USS PURSUIT survey, while the ATLANTIS found an established system (the reverse of the accepted pattern) which began shifting before her departure. By the time the USS SAN PABLO surveyed the area 6 weeks later, the system of east-to-west movement was re-established. Figures 6, 7, and 8 show the GEK data obtained by the three ships.

The striking differences in the data from the three ships imply a current system far more flexible than was previously believed to exist. The high surface current speeds found in all three surveys are previously unrecorded features of the circulatory system, as is the large eddy inferred from the USS SAN PABLO observations. This eddy must be of a most transient nature, otherwise it could scarcely have escaped notice so long. Of equal interest are the apparent similarities found during the three surveys, particularly the eddy off Punta Maisi and the persistent eastward drift along the southern coast of Cuba.

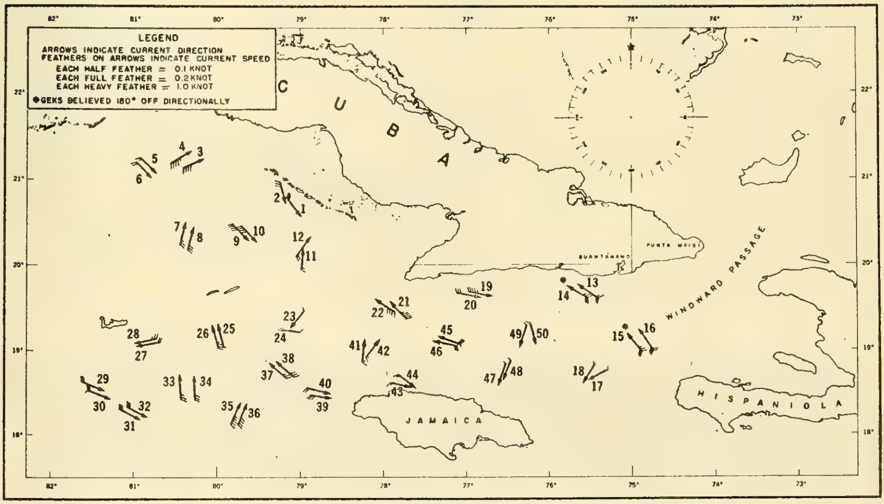

Fig. 6. Surface currents USS PURSUIT GEK observations 14-28 March 1953

USS PURSUIT (fig. 6). Currents set southeastward through the northern and southwestern parts of the area with a westward counterflow through the western central section. If GEK's 13-14 and 15-16 are reversed 180°, observations in the eastern portion of the area support the ATLANTIS findings.

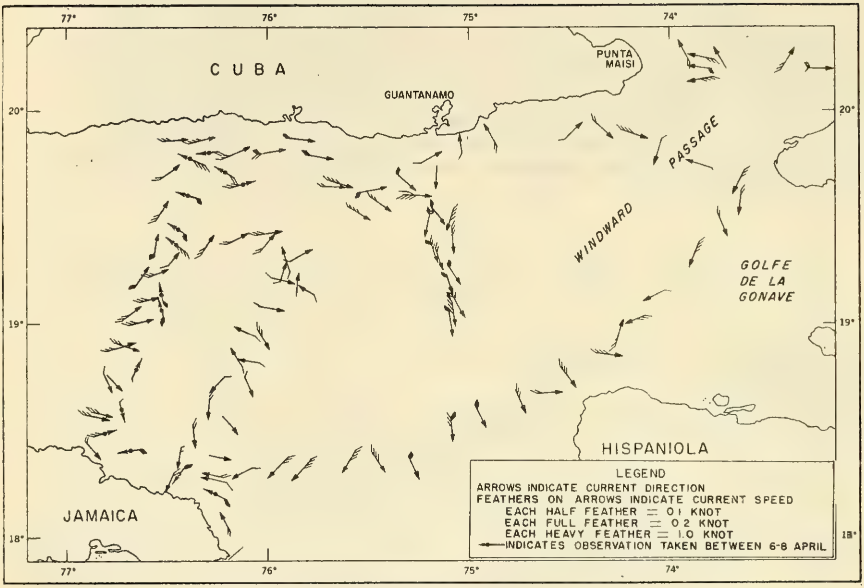

Fig. 7. Surface currents RV ATLANTIS GEK observations 18 March to 13 April 1953

RV ATLANTIS (fig. 7). Eastward and southeastward drift occurs throughout the central section; thence movement is southward between Jamaica and Hispaniola. Currents set northeastward across Windward Passage. An eddy forms off Punta Maisi (Cape Maysi). Between Windward Passage and Hispaniola, movement is southwestward and thence southward.

Between Jamaica and Hispaniola, where surface and subsurface drogues were used in addition to the GEK, the ATLANTIS found strong southward currents in the top 200 meters.

The two westernmost sections were obtained on 24 March and 6 through 8 April, reading from left to right. The earlier series of observations showed all flow moving eastward. Subsequently, a definite shift was noted, except along the southern coast of Cuba, where the eastward drift persisted.

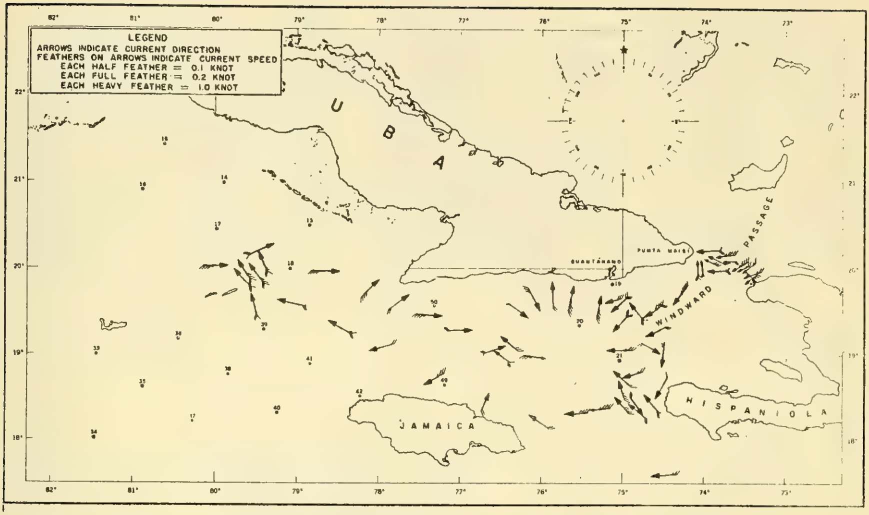

Fig. 8. Surface currents USS SAN PABLO GEK observations 29 May to 9 June 1953

USS SAN PABLO (fig. 8). Currents setting to the west and southwest show water entering the area through Windward Passage. The eddy off Punta Maisi is clearly indicated. The movement between Hispaniola and Jamaica is the reverse of that found by the RV ATLANTIS. Subsequent drift is westward and northwestward. A countercurrent flows eastward along the southern coast of Cuba. A large eddy is indicated extending from Guantanamo to the passage between Hispaniola and Jamaica.

III. TRANSPORT

Before proceeding with a discussion of calculated volume transport, it must be pointed out that there was a time difference of 7 weeks between the first and last oceanographic stations occupied by the USS PURSUIT. In the light of the subsequent surveys by the ATLANTIS and USS SAN PABLO, it is apparent that the circulation was in a transient state during both USS PURSUIT surveys. Nevertheless, the data from each group have been integrated and transport and relative currents calculated to see how they compared with the GEK results.

Volume transport has been calculated from USS PURSUIT data above a depth of stability having a sigma-t value of 27.52, which averages 920 meters over the entire area. It was felt that this would be more accurate quantitatively than referring the calculations to 1,200 meters, as was done with the dynamic topography, although the horizontal flow is almost uniform to this depth. At each station, the weighted mean anomaly was calculated referred to the depth at which sigma-t was equal to 27.52 as read from STD curves. The direction and volume of transport is shown in figure 9. Total volume transport as calculated is 45 x 10^6 m^3/sec through the area, with an error of 2.4% between incoming and outgoing transport. The presence of internal tides (inferred by figure 14 and discussed under VI. Tidal Influence) may account for the error.

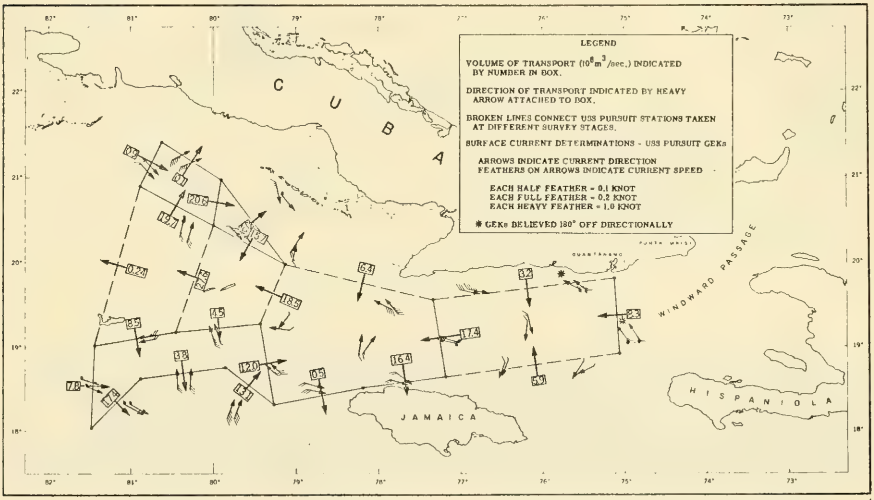

Fig. 9. Direction and volume of transport calculated to an average depth of 920 meters -- USS PURSUIT data

For the most part, the GEK's are in good agreement with the calculated transport directions. Where the strong currents in disagreement are found, 2 sets, GEK's 25-26 and 27-28, may be explained by winds of 10 to 14 knots (high for the time of year) occurring 18 to 20 hours earlier. For GEK's 37-38 no simple explanation presents itself, but other observations taken the same day in the same general area support the calculated transport direction. Too much importance should not be attached to the discrepancies, however, since it was in this area that the time lag between GEK's and oceanographic stations was greatest.

IV. CURRENT VELOCITIES

The presence of surface currents exceeding one knot was noted throughout the area by the three ships. Currents of this magnitude are not recorded on any charts of the area. The calculated velocities shown in figures 10 and 11 are further evidence of the existence of amounts in excess of 1 knot. Figure 10 represents the velocity through cross sections computed from volume transport. Figure 11 depicts surface speeds as determined by dynamic topography relative to 400 meters. It is considered of slight importance that the determined velocities do not agree quantitatively with the GEK's, since the computed currents are averages across sections often exceeding 60 miles in length. The significant feature is that the magnitudes of the calculated currents and of the GEK's agree well in most cases.

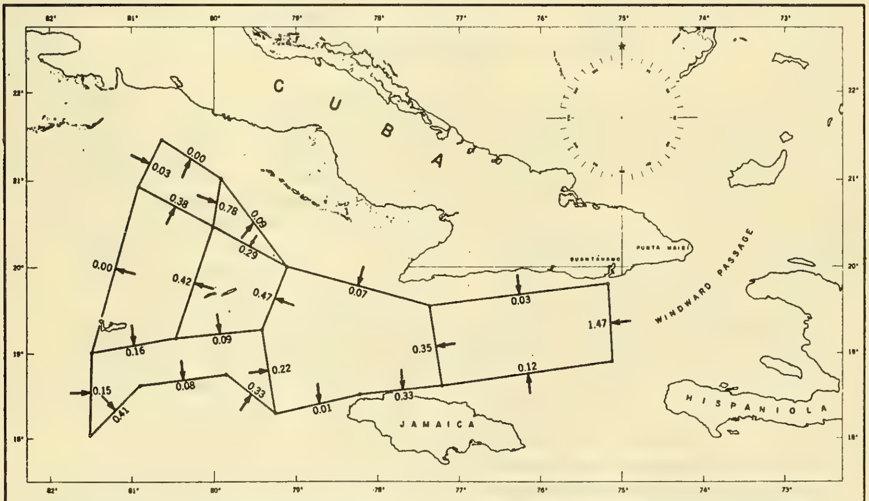

Fig. 10. Current speeds (knots) calculated from volume transport through cross sections of 920 meters average depth

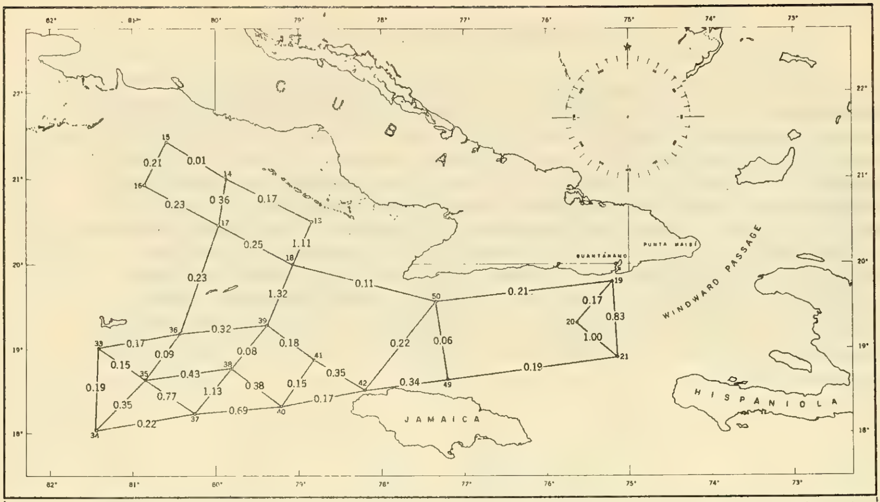

Fig. 11. Surface current speeds (knots) computed from dynamic topography relative to 400-meter level

V. WATER MASS CHARACTERISTICS

Temperature-salinity correlations are plotted in figures 12a and 12b together with a mean curve for the Yucatan Channel (redrawn from Iselin, 1936) which serves as a basis for comparison. The plots in figure 12a represent those stations having the lowest dynamic heights relative to 400 meters (see fig. 5), and as such are each a part of an enclosed circulation. The plots include stations both in the first and last phase of the PURSUIT survey. In general, the T-S correlations below 200 meters in figure 12a fall farther to the right of the Yucatan Channel curve than do the correlations in figure 12b, which represent stations taken in the southwestern section of the survey area (latter phase of survey). The stations in the northwest section have been excluded from these composites; however, selected portions of their T-S diagrams are shown in figure 13. Of these, the curve for station 17 best fits the correlations in figure 12b. The water in the central section seems fairly well mixed with the water from the southwest and east, while in the northwestern area progressive mixing in the maximum salinity layer (150 to 250 meters) is observed.

The transport calculations across stations in the northwest section (taken in the first phase of the USS PURSUIT cruise) indicate an eddy system involving a considerable quantity of water, which is not borne out by the T-S diagrams. In spite of the time lag between phases of the cruise, it is apparent that a fair proportion of this water must therefore be diverted southward, as the transport computations using station data from the second phase of the cruise show.

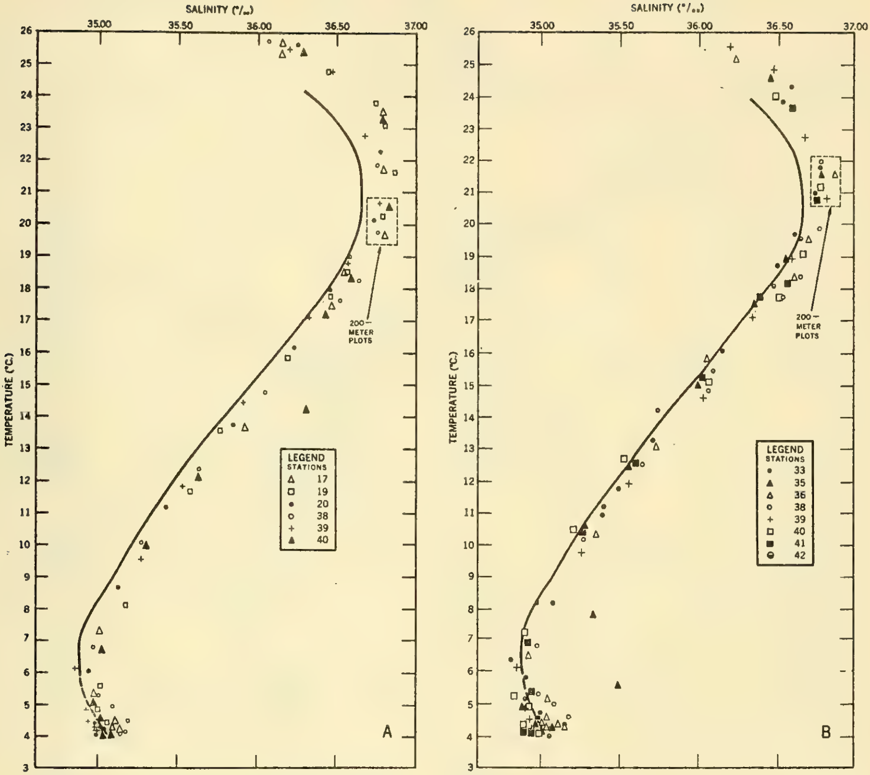

Fig. 12. Comparison of USS PURSUIT T-S data and T-S curve for Yucatan Channel, redrawn from Iselin, 1936 - (a) PURSUIT stations having lowest dynamic heights relative to 400 meters; and (b) PURSUIT stations taken in southwestern section during latter phase of survey

VI. TIDAL INFLUENCE

No tidal currents are in evidence except perhaps close inshore. However, data from an anchor station occupied by the USS SAN PABLO between Hispaniola and Jamaica give the interesting result shown in figure 14, where current speed at the surface is plotted against time. The curve closely resembles that of a tidal cycle although there is little change in direction. It is believed that any tidal influence is usually masked by the larger circulatory picture.

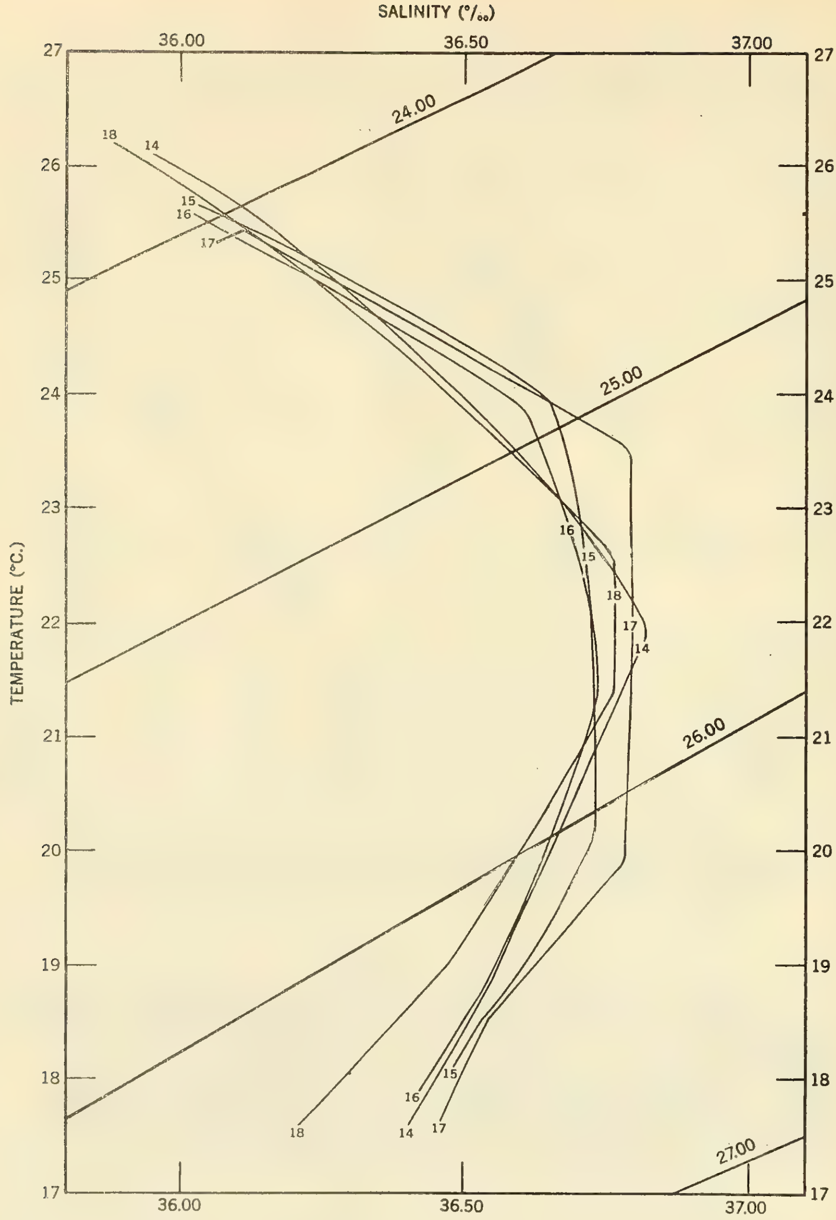

Fig. 13. Selected portions from temperature-salinity curves of USS PURSUIT stations in the northwestern section of the survey area

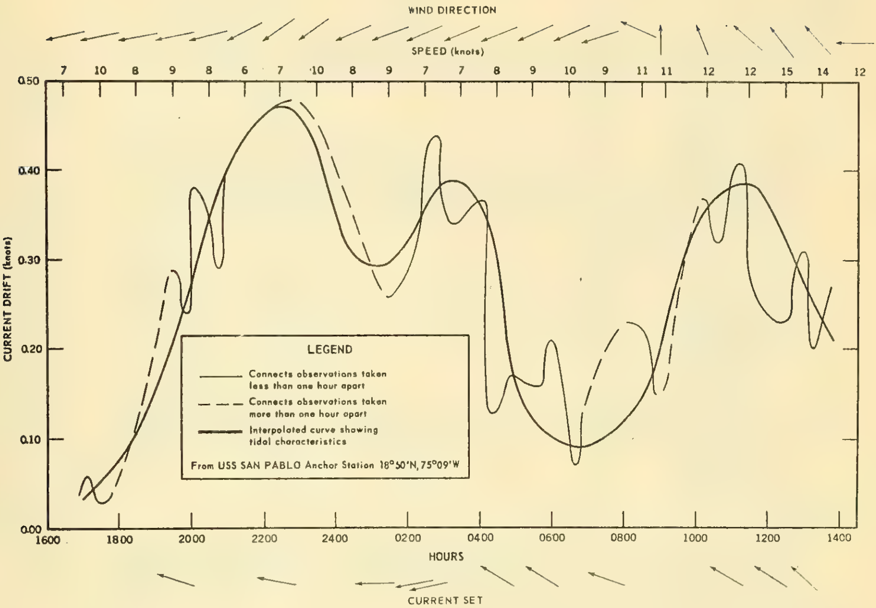

Fig. 14. Surface-current measurements exhibiting tidal characteristics

VII. CONCLUSIONS

Considerably more work should be done toward integrating meteorological conditions in the Gulf of Mexico and the North Atlantic with the current system in this study area. If this is done, it might be possible to predict the system which would exist at a specific time, or at least define the percentage of time an eastward or westward drift might be expected.

In addition, further interpretation of the T-S diagrams should be attempted before this study may be considered as more than a preliminary report.

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